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(54) DEVICE FOR VENTILATING A PATIENT

(71) We, AGA AKTIEBOLAG, of S-181 81 Lidingo, Sweden, a Swedish Company, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a device for connecting a patient by means of an endotracheal tube or a tracheal cannula to a lung ventilator which comprises a gas source for the desired breathing gas and a controlled valve device for intermittent and periodic feeding of breathing gas from the gas source. The device according to the invention is especially intended for the connection of a patient to a lung ventilator which is designed for high frequency overpressure ventilation, so called HFPPV, but the device according to the invention may also be used in other types of lung ventilators.

When ventilating a patient by means of a lung ventilator it is desirable to have a considerably greater freedom as to the treatment of the patient than is possible when using the ventilation devices previously available. Thus it is exceedingly desirable that during the ventilation by means of the ventilator, the patient has also the freedom to breathe spontaneously and that the spontaneous breathing is not prevented by or in conflict with the ventilation by means of the ventilator used. Further it is of great advantage if during the ventilation of the patient, instruments can be inserted into the trachea of the patient, especially for cleaning the air-passages of the patient but in certain cases also for other purposes, such as for taking samples or for visual observation of the air-passages. Further it is desirable to be able to work with an adjustable overpressure at the end of the expiration phase of the ventilation. It is also of advantage if, during the ventilation of the patient by means of an automatically working ventilator, it is possible to ventilate the patient manually by means of a rubber bag, bellows or the like, without this manual ventilation coming into conflict with the function of the automatic lung ventilation. In modern respirator practice it has proved to be desirable to pass quickly and in a simple manner from a positive ventilation of the patient by means of the automatically working ventilator used to a treatment according to the so called CPAP (continuous positive airway pressure), which means that the patient is continuously supplied with desired breathing gas under a constant predetermined overpressure but that the patient himself has to do the breathing work by means of spontaneous breathing. Then there is of course the always present requirement that the ventilation of the patient must be carried out in a way ensuring complete safety for the patient.

According to the present invention there is provided a device for the ventilation of a patient by means of a lung ventilator which comprises a gas source and a valve arrangement for controlling the supply of breathing gas from a gas source, wherein said device comprises a substantially straight main tube, one end of which is connectable to or is part of an endotracheal tube or tracheal cannula insertable into a patient, and a branch tube in valveless connection with the main tube at a location remote from said one end thereof, the part of the branch tube near the main tube forming an acute angle with the main tube and being directed towards said one end of the main tube, a non-return valve admitting inflow of air and a pressure relief valve being arranged in the wall of the branch tube or in the wall of

the main tube between said one end of the main tube and the connection point of the main tube with the branch tube.

In the following the invention will be described in detail in connection with the attached drawings, which illustrate some embodiments of the invention, whereby

Fig. 1 schematically shows a first embodiment of arrangement according to the invention, which allows ventilation of the patient by means of a lung ventilator and simultaneously spontaneous breathing of the patient as well as insertion of instruments in the trachea of the patient and

Fig. 2 schematically shows a further arrangement according to the invention, which moreover allows variable adjustment of the end expiratory pressure, manual ventilation of the patient and a CPAP treatment.

The arrangement according to the invention, schematically and as an example shown in Fig. 1, comprises a connecting piece 1 between an endotracheal tube or tracheal cannula 2 inserted into the trachea of the patient and the utilized lung ventilator 3. The lung ventilator 3 can in principle be of an arbitrary kind, but is assumed, for simplicity's sake, in the following description to be of a type designed for HFPPV ventilation. The lung ventilator 3 comprises a gas source for the desired breathing gas (with necessary arrangements for determining the composition of the breathing gas, temperature, content of humidity and pressure) and a controlled valve arrangement 3*a* for intermittent feeding of the breathing gas with a desired, usually variably adjustable frequency and variably adjustable relation between the duration of each gas feed and the duration of the intermediate intervals.

The connecting piece 1 according to the invention comprises a main tube 4, one end 4*a* of which is connected to the endotracheal tube or tracheal cannula 2 inserted into the patient, and a branch tube 5 one end 5*a* of which emerges into the main tube 4, and the other end 5*b* of which is connected to the ventilator 3 via a conduit 6 only schematically shown in the drawing.

The connection part between the main tube 4 and the branch tube 5 is so designed, in virtue of the acute angle, that it directs essentially all the gas that flows from the ventilator 3 through the branch tube 5 into the main tube 4 in the direction towards the end 4*a* of the main tube, as indicated by the arrows 7. Furthermore, free gas flow is allowed in both directions through the main tube 4 past the orifice 5*a* of the branch tube 5, as indicated by the arrows 8.

Thus, during the insufflation period of the ventilator 3, breathing gas is flowing from the ventilator 3 through the branch tube 5 and then on through the end 4*a* of the main tube 4 into the endotracheal tube of tracheal cannula 2 and into the lungs of the patient. During the following exhalation period of the work cycle of the ventilator 3, during which no breathing gas is fed from the ventilator, the consumed breathing gas will, due to the elasticity of the lungs of the patient, be pressed out of the lungs through the endotracheal tube 2 and further through the main tube 4 in the connection piece 1 and out into the surrounding atmosphere at the end 4*b* of the main tube.

The ventilation of the patient by means of the lung ventilator 3 may proceed unobstructed even if an instrument is simultaneously inserted into the trachea of the patient through the main tube 4 of the connection piece 1 and the endotracheal tube 2 for instance for sucking clean the air-passages of the patient.

Furthermore, if the patient so wishes, he can breathe spontaneously through the main tube 4 of the connection piece 1 without this spontaneous breathing being in any way conflicted by the ventilation effected by the ventilator 3. If the spontaneous exhalation of the patient should coincide with an insufflation phase of the ventilator 3, during which breathing gas is supplied to the branch tube 5 from the ventilator, then breathing gas flowing from the branch tube 5 into the main tube 4 will be influenced by the spontaneous expiration of the patient and turned off upwards in the direction towards the end 4*b* of the main tube 4, so that the breathing gas supplied from the branch tube 5 as well as the gas spontaneously exhaled by the patient flow out from the end 4*b* of the main tube 4. Thus, the patient has full freedom to breathe spontaneously during the ventilation by the ventilator 3.

The wall of the main tube 4 is provided with a diaphragm valve 9 functioning as a non-return valve, which allows only the inflow of air from the surrounding atmosphere into the main tube 4. When breathing spontaneously it is possible for the patient to inhale air through this non-return valve 9, as indicated by the dashed arrow 10, if the end 4*b* of the main tube 4 should be closed either unintentionally or deliberately in accordance with a further development of the invention which will be described hereinafter.

The wall of the main tube 4 is also provided with a pressure-relief valve 11 having an adjustable opening pressure.

which allows outflow of gas from the interior of the main tube 4 to the surrounding atmosphere if the pressure inside the lower part of the main tube 4 is higher than the set opening pressure of the valve. This pressure-relief valve 11 has a double function. On one hand it guarantees that during the insufflation period of the ventilator 3 the pressure at the end of the endotracheal tube 2 adjacent the tube 4 does not exceed a desired maximum value. On the other hand it makes possible the exhalation of the patient, as marked by means of the dashed arrow 12, if the end 4*b* of the main tube 4 should be closed.

The non-return valve 9 and the valve 11 may alternatively be placed in the branch tube 5 instead of in the main tube 4. This may be especially advantageous in an arrangement intended to be used for babies, since here the shortest possible exhalation passage from the patient is desired, viz a short main tube 4.

The part of the main tube 4 adjacent end 4*a* is also provided with a recess 13 for connection to a manometer 14 for measuring and registering the pressure at the end of the endotracheal tube 2 adjacent the tube 4.

A device according to the invention, shown in Fig. 1 and described above, allows positive ventilation, for instance HFPPV ventilation of a patient by means of a suitable ventilator, and simultaneously allows the patient the freedom to breathe spontaneously, and also allows instruments to be inserted into the trachea of the patient. On the other hand, this simple device does not allow an adjustment of an end expiratory overpressure, a CPAP treatment or a manual ventilation of the patient. These are however possible by means of the further development of the device shown schematically and as an example in Fig. 2.

The connecting piece 1, shown in Fig. 2, consisting of the main tube 4 and the branch tube 5 is designed in exactly the same way as in Fig. 1 except that the non-return valve 9 and the pressure-relief valve 11 are located in the branch tube 5 instead of in the main tube 4. In a modification of the embodiment shown in Fig. 2 the non-return valve 9 and the pressure-relief valve 11 could be arranged at the lower part of the main tube 4 adjacent end 4*a*.

The end 4*a* of the main tube 4 is, as before, connected to the endotracheal tube 2 inserted in the patient, whereas the outer end 5*b* of the branch tube 5, by means of the conduit 6, is connected to the lung ventilator 3 and its controlled intermittently working valve 3a.

The end 4*b* of the main tube 4, does not open directly to the surrounding atmosphere but is connected to a valve device, generally designated 15, detachably mounted on the main tube 4. The valve housing 16 of the device 15 is substantially formed as a T-shaped tubular structure, which comprises an automatically working diaphragm valve 17, which allows alternatively either gas to flow from the main tube 4 into the part of the valve housing 16 shown on the left-hand side of the tube 4 in Fig. 2, as indicated by an arrow 18, if the gas pressure in the end 4*b* of the main tube 4 is higher than that inside the valve housing 16, or gas to flow into the main tube from the part of the valve housing 16 shown on the right-hand side of the tube 4 in Fig. 2, as indicated by an arrow 19, if the gas pressure in the right part of the valve housing 16 is higher than in the end 4*b* of the main tube 4. The right-hand part in the drawing of the valve housing 16 is provided with a shut-off valve 20 which in the embodiment shown is manually controllable, and which is connected to a rubber bag 21, or the like, of the kind normally used for manual ventilation of a patient. Further, between the shut-off valve 20 and the rubber bag 21 there is a non-return valve 22 for allowing intake of gas into the rubber bag 21. This non-return valve 22 can be in communication with the surrounding atmosphere, as shown in the drawing, or can in a conventional manner be connected to a suitable oxygen source.

The left-hand part (in the drawing) of the valve housing 16 is provided with a pressure-relief valve 23 having a variably adjustable opening pressure. This pressure-relief valve 23 serves as an exhalation valve and can either communicate with the surrounding atmosphere as shown in the drawing, or be connected to a suitable conventional gas volume meter for measuring the gas volume exhaled.

If the shut-off valve 20 is in its closed position viz. no manual ventilation of the patient is desired, the ventilation of the patient will be carried out wholely by means of the lung ventilator 3 in the manner described above in connection with Fig. 1, whereby during the exhalation period 3 the consumed breathing gas flows from the lungs of the patient through the main tube 4, past the diaphragm valve 17 (the arrow 18) and out through the valve 23. The maximum expiratory pressure can be set by adjusting the opening pressure of the valve 23. The patient has still the freedom to breathe spontaneously in a similar manner as in the arrangement according to Fig. 1, whereby the inhalation takes place through the non-return valve 9, whereas the exhalation takes place through the exhalation valve 23. If for some reason the ventilation device 15 should not function

but should choke the exhalation passage, just described, the exhalation can take place through the pressure-relief valve 11 in the branch tube 5.

One can easily and quickly switch from such an intermittent ventilation of the patient by means of the lung ventilator 3 to a CPAP treatment, simply by maintaining the valve 3*a* from the ventilator 3 permanently in an open condition, so that the patient will continuously be supplied with the breathing gas. Hereby, the patient will be breathing spontaneously and inhale the breathing gas from the ventilator 3 via the branch tube 5 and exhale through the valve 23, the setting of which thus determines the pressure for the CPAP treatment.

If manual ventilation of the patient is desired, the shut-off valve 20 is opened, so that the rubber bag 21 is put in connection with the main tube 4 via the diaphragm valve 17. Thus, when the rubber bag 21 is compressed, gas is pressed past the diaphragm valve 17 (the arrow 19) into the main tube 4 and thereafter down into the lungs of the patient. When the rubber bag 21 is thereupon released, the diaphragm valve 17 automatically changes its position, so that gas may flow out from the lungs of the patient past the diaphragm valve 17 (the arrow 18) and out through the valve 23. Simultaneously new gas or air is sucked into the rubber bag 21 through the non-return valve 22. Thus one obtains a manual ventilation of the patient.

If one should wish to insert any instrument into the trachea of the patient, this can be done by temporarily removing the valve device 15 from the upper end 4*b* of the main tube, whereafter the desired instrument easily can be inserted down into the trachea of the patient through the main tube 4, with simultaneous ventilation of the patient by means of the ventilator 3.

If one does not wish to have the possibility of ventilating the patient manually, the rubber bag 21 with the suction valve 22, the manual shut-off valve 20 and the diaphragm valve 17 can of course be left out, so that the valve device 15 will only comprise the adjustable exhalation valve 23.

It is evident that more modifications of the arrangements shown in Figs. 1 and 2 and described above, are possible within the scope of the invention as defined in the appended claims. Thus the manually operated shut-off valve 20 in the device according to Fig. 2 may be substituted by a spring-loaded nonreturn valve, which opens only when the pressure inside the rubber bag 21 exceeds the pressure in the remaining part of the valve housing by a predetermined value, when the rubber bag is compressed. Finally, the connecting piece 1 could form a part of the endotracheal tube 2, instead of being detachably connected to it.

WHAT WE CLAIM IS:—

1. Device for the ventilation of a patient by means of a lung ventilator which comprises a gas source and a valve arrangement for controlling the supply of breathing gas from the gas source, wherein said device comprises a substantially straight main tube, one end of which is connectable to or is part of an endotracheal tube or tracheal cannula insertable into a patient, and a branch tube in valveless connection with the main tube at a location remote from said one end thereof, the part of the branch tube near the main tube forming an acute angle with the main tube and being directed towards said one end of the main tube, a non-return valve admitting inflow of air and a pressure relief valve being arranged in the wall of the branch tube or in the wall of the main tube between said one end of the main tube and the connection point of the main tube with the branch tube.

2. Device as claimed in claim 1, wherein the opening pressure of the pressure relief valve is adjustable.

3. Device as claimed in claim 1, wherein the other end of the main tube is in direct connection with the surrounding atmosphere.

4. Device as claimed in claim 1, wherein the other end of the main tube is connected to a second pressure relief valve having an adjustable opening pressure.

5. Device as claimed in claim 4, wherein the other end of the main tube is connected via a three-way valve on the one hand to said second pressure relief valve and on the other hand to a rubber bag for manual ventilation, whereby said three-way valve is arranged to adopt one position thereof only when the rubber bag is compressed and thereby admit flow of gas from the rubber bag into the main tube and otherwise to adopt another position and thereby admit flow of gas from the main tube to the second pressure relief valve.

6. Device as claimed in claim 5, wherein a shut-off valve is arranged between the rubber bag and the three-way valve.

7. Device as claimed in claim 5,

wherein said three-way valve is arranged in a valve housing detachably mounted at the other end of the main tube.

8. Device for the ventilation of a patient substantially as hereinbefore described with reference to Figure 1 of the accompanying drawings.

9. Device for the ventilation of a patient substantially as hereinbefore described with reference to Figure 2 of the accompanying drawings.

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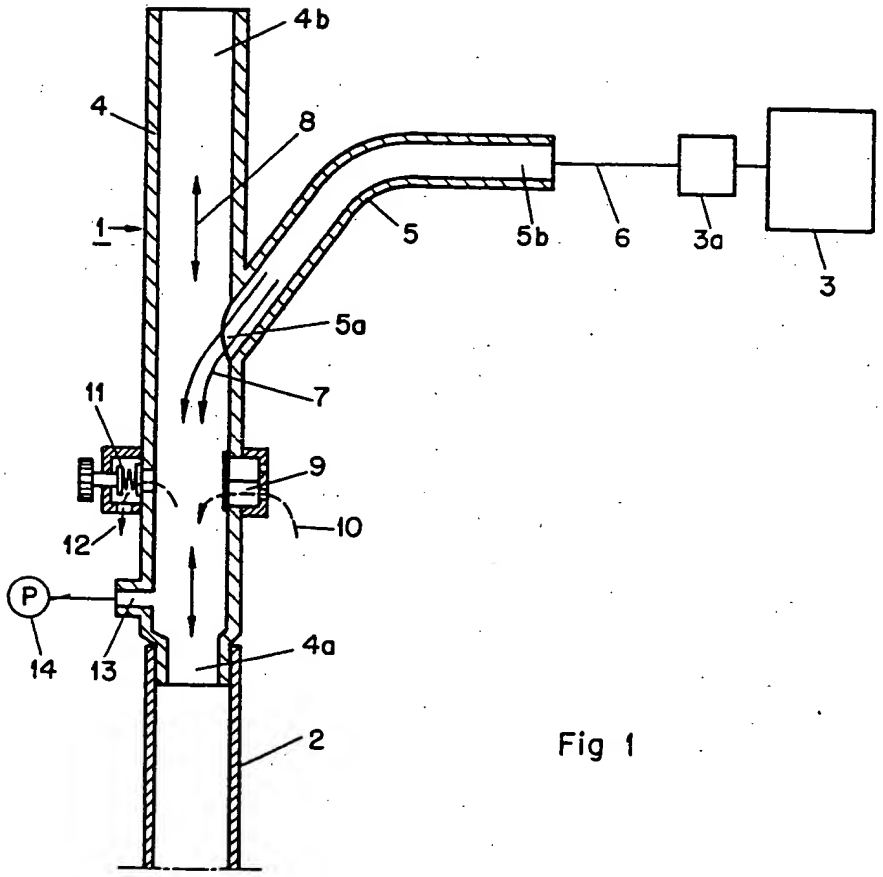

Fig 1

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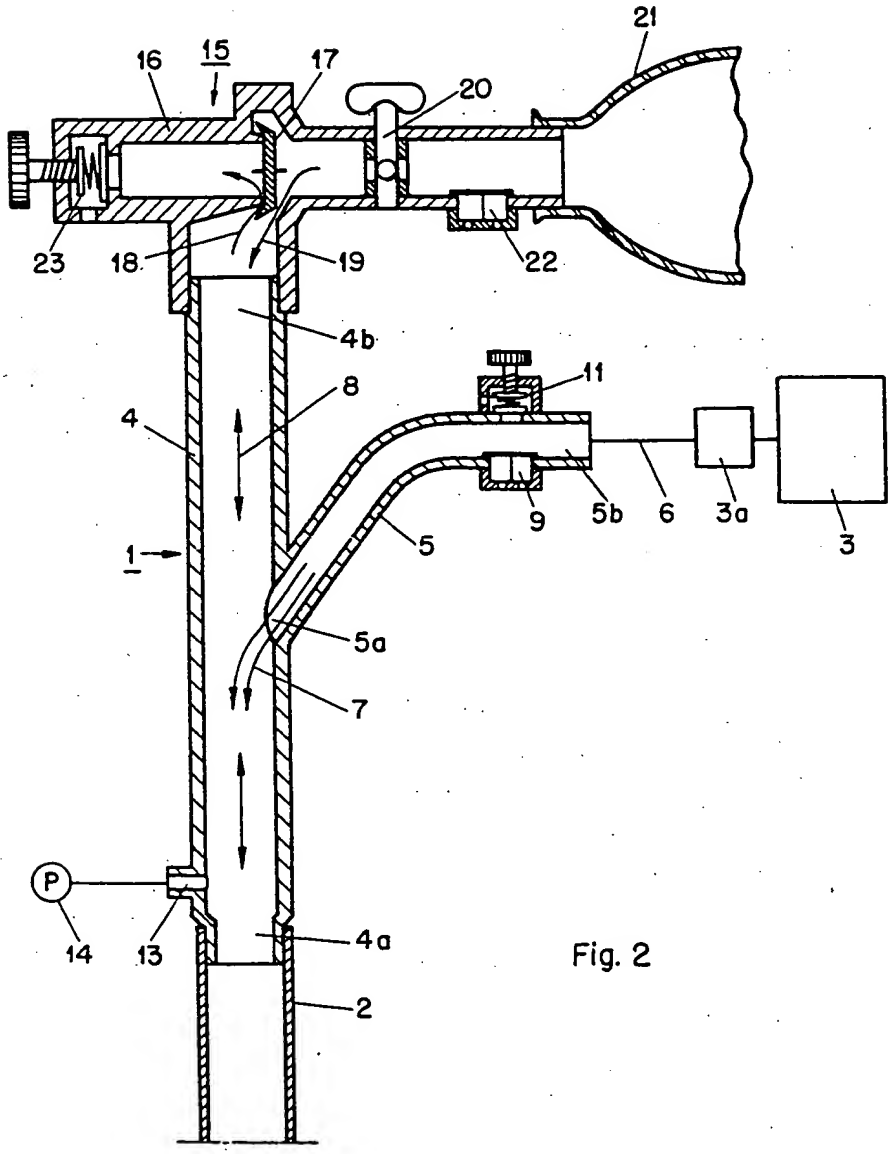

Fig. 2